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Studies of correlation and path analysis in normal and late sown condition in wheat genotypes (*Triticum aestivum* L.) for heat tolerance

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Abstract
The field experiment was conducted to study the "Morpho-physiological and biochemical studies for heat tolerance traits in wheat (*Triticum aestivum* L.) genotypes." at the farm of Wheat and maize Research Unit, Vasantrao Naik Marathwada Agriculture University, Parbhani, during *Rabi* season of 2020-21 and 2021-22. Total 16 genotypes collected from Wheat and maize Research Unit, VNMAU, Parbhani was taken to conduct the experiment. Each treatment was replicated two times. The experiment was laid out in simple lattice design. The high temperature stress was induced by manipulation of sowing dates. Different morpho-physiological traits *viz.*, tillers per meter row length, relative water content, membrane stability index, chlorophyll content, canopy temperature, and total dry matter production were found to be correlated with grain yield. These traits may be used in breeding programme for development of thermo tolerant genotypes for late condition under changing climatic scenario. Plant height at 90 days after sowing showed positive significant correlation with grain yield, number of tillers 45 DAS, Flag leaf area 60 DAS, chlorophyll content 15 DAA and chlorophyll content 21 DAA. The characters *viz.*, leaf area, chlorophyll content 15 DAA, canopy temperature 15 DAA and canopy temperature 21 DAS showed high direct effect on grain yield per plant.

Keywords: Correlation and path analysis, heat stress, simple lattice design, wheat genotypes

1. Introduction
Wheat (*Triticum aestivum* L.) is a crop of the gramineae family and is native to South West Asia. It is the most widely grown food crop in the world and is therefore referred to as the "King of all cereal crops" due to its ease of cultivation, economic viability, and high nutritious content. It is rich in vitamins, minerals, gluten, calcium, lysine, and carbohydrates. It contains 7–12 percent protein. After rice, it is the second-most significant crop in India. Wheat needs a temperature of 15 °C to grow and mature at its best. It may be cultivated everywhere from temperate, irrigated, arid, and high rainfall regions to warm, humid, and dry, cold climates.
Since the commencement of the wheat revolution in India in 1967, the amount of land planted with wheat has gradually surged and so was production and productivity. Wheat output worldwide totals 584.76 MT, with an area of 215.26 Mha and a productivity of 2715 kg/ha. It occupied a 31.35 Mha area in India in 2019–2020, producing 107.86 MT overall and producing at a productivity of 3440 kg/ha. It occupied 1056 Mha in the state of Maharashtra, producing 1793.68 MT overall and 1697 kg/ha on average. (Anonymous, 2020) [1].
The shortest developmental stages caused by high temperatures, lower light perception across the shorter life cycle, and disruption of the carbon absorption mechanisms are the main causes of heat stress-related yield loss in wheat transpiration, photosynthesis and respiration. (Stone, 2001) [12]. According to the climate change scenarios, the main wheat-growing regions with seasonal temperatures are predicted to increase by 1.0–1.5 °C, 2.5–4 °C, and 4.5 °C, respectively, in 2020, 2050, and 2080. According to several international assessments, India's crop production would decrease by 10–40% by the end of the century (Stern, 2007) [11].
Taking in to the consideration of transpiration, photosynthesis and respiration which is subjected to the heat-stress related yield loss, here we enlightened results on correlation and path analysis studies in the wheat, to identify the correlation and direct and indirect effect in the path analysis.

2. Materials and Methods

2.1 Experimental layout

The experiment was carried out at 'Wheat and Maize Research Unit, Vasantarao Naik Marathawada Agriculture University, Parbhani, MS, India in two seasons i.e., *Rabi* 2020-21 and *Rabi* 2021-22. Randomization of treatments was made in both the seasons 32 treatments (16 x 2) were laid out in a simple lattice design with two replications. The high temperature stress was induced by manipulation of sowing dates i.e., normal sowing and late sowing. All agronomic packages of practices were carried out as per recommendation for raising the quality crop.

2.2 Experimental material

Experiment comprises of 16 genotypes collected from Wheat and Maize Research Unit, VNMAU, Parbhani, MS, India. This includes 10 checks and 6 germplasms. Genotypes used in the study are mentioned in Table 1.

Table 1: Genotypes used in the experiment for correlation and path analysis in Wheat

Sr. No.	Genotype	Sr. No.	Genotype
1	MP-3288	**9**	HI-8823 (d)
2	MACS-4058 (d)	**10**	MACS-3949 (d)
3	HI-1636	**11**	AKDW-2997-16 (d)
4	UAS-446 (d)	**12**	MP-1358
5	HI-8805 (d)	**13**	HD-3090
6	DDW-47 (d)	**14**	WH-730
7	DBW-150	**15**	HI-1544
8	HI-1605	**16**	GW-513
(d) indicates *Durum* wheat			

2.3 Observation recorded

Different morpho-physiological traits *viz.*, tillers per meter row length, relative water content, membrane thermo stability index, chlorophyll content, canopy temperature, total dry matter production, flag leaf area were recorded on plant basis i.e. represented 5 plants from the plots except tillers per meter row length, which is recorded on a plot basis. Electrical conductivity (EC) meter was used to analyze membrane thermo stability index. SPAD meter is used for measuring chlorophyll content from the leaf. Hand Infrared thermometer was used for measuring canopy temperature and automatic leaf area meter was used for measuring flag leaf area.

2.4 Statistical analysis

The analysis of variance was performed as to get the significance of differences between the treatments for all the characters as per the methodology suggested by Jayaraman (1999). The statistical model used for the design was as followes;

$$Y_{ijk} = \mu + \pi_i + \beta_{i(l)} + T_j + E_{ij(l).}$$

Where,
Y_{ijk} = Response value of i^{th} treatment in the i^{th} block within i^{th} replication
μ = effect of mean
π_i = effect of replicate
$\beta_{i(l)}$ = effect of incomplete block
Ti = effect of treatment
$E_{ij(l)}$ = effect of intra block residual
The analysis of variance based on this model is given in the Table 2.

Table 2: Analysis of variance for experimental design

Source of variance	Degree of Freedom	Sum of Squares	Mean sum of Squares	Fcal
Replications	(r-1)	SSR	MSR	MSR/MSE
Treatments (unadjusted)	(k^2-1)	SST(adj.)	MST	MST (unadjusted) / MSE
Blocks within replication (adjusted)	r(k-1)	SSB	MSB (adj.)	MSB (adjusted) / MSE
Intra block error	(k-1) (rk-k-1)	SSE	MSE	-
Total	rk^2-1	-	-	-

3. Result and discussion

3.1 Correlation coefficient (r)

Correlation refers to the degree and direction of association between two or more variables (Toor, 2020) [13]. Correlation enables to identify the characters or combination of characters which might be useful as indicator of high yield by way of evaluating relative influence of various characters on yield and among themselves as well. The original concept of correlation was given by Galton (1889) [4] and later elaborated by Fisher (1936) [3].

3.1.1 Correlation coefficient among different morpho-physiological traits under normal sown condition

Data presented in Table 3 and Figure 1 indicated that, the character plant height at 90 days after sowing showed positive significant correlation with grain yield (r = 0.706) followed by number of tillers 45 DAS (r = 0.685), flag leaf area 60 DAS (r = 0.560) and membrane thermo stability 60 DAS (r = 0.500).

Number of tiller 45 days after sowing exhibited significant positive correlation with grain yield (r = 0.638) which is followed by membrane thermo stability 60 DAS (0.383), chlorophyll content 15 DAA (0.361) and chlorophyll content 21 DAA (r = 0.377) and negative significant association with relative water content 60 DAS (r = -0.426), indicates that increasing tillers significantly increases yield but reduces relative water content in the plants.

Leaf area at 60 DAS has shown positively significant correlation with total dry weight 90 DAS (r = 0.741), relative water content 60 DAS (r = 0.538) and canopy temperature 15 days after anthesis (r = 0.545).

Flag leaf area 60 DAS exhibited positively significant correlation with grain yield (r = 0.454) followed by membrane thermo stability index 60 days after sowing (r = 0.533) content 15 days after anthesis (r = 0.412) and 21 days after anthesis (r = 0.437) illustrating that more leaf area exhibited at 60^{th} day after sowing significantly promotes grain yield.

Total dry matter production at 90 DAS significantly negative correlation associated with grain yield (r = -0.441) and chlorophyll content 15 DAA (r = -0.541) however, this trait exhibited significantly positive correlation with relative water content 60 DAS (r = 0.547) and canopy temperature 15 DAA (r = 0.526) this clearly indicates that increasing biological yield reduces grain yield in wheat whereas it increases relative water content and canopy temperature as biological

growth of the plant promotes relative water content.

Chlorophyll content 15 Days after anthesis (DAA) exhibited significantly positive correlation with grain yield per plot (r = 0.554) and chlorophyll content 21 DAA (r = 0.842), resulting that increasing chlorophyll content in leaves increases the seed yield as plants promotes photosynthesis activity and reduces the photorespiration.

Canopy temperature 15 DAA exhibited positively significant correlation with grain yield (r = 0.740) and canopy temperature 21 DAA (0.731). Qaseem *et al.* (2019) [9] revealed that the grain yield had highest positive correlation with plant height (r = 0.71) and relative water content (r = 0.69). Under heat stress grain yield had strongest correlation with harvest index (r = 0.54) and grains per spike (r = 0.51). Neeru *et al.* (2017) [8] revealed that grain yield showed positive and significant correlation with effective tillers per meter, canopy temperature, but correlated negatively and significantly with plant height under timely sown condition.

Table 3: Correlation coefficient among different morpho-physiological character with grain yield under normal sown condition

Genotypic correlation matrix												
	PH (cm) 90 DAS	**NOT 45 DAS**	**LA 60 DAS**	**FLA 60 DAS**	**TDW 90 DAS**	**MST 60 DAS**	**CC 15 DAA**	**CC 21 DAA**	**RWC 60 DAS**	**CT 15 DAA**	**CT 21 DAA**	**GY**
PH (cm) 90 DAS	1.0000	0.685**	-0.2172	0.560**	-0.1903	0.500*	0.380*	0.404*	-0.3056	0.1490	-0.2078	0.706**
NOT 45 DAS		1.0000	0.2480	0.1951	0.1853	0.383*	0.361*	0.377*	-0.426*	0.422*	-0.2723	0.638**
LA 60 DAS			1.0000	-0.0212	0.741**	-0.1061	0.1072	0.1130	0.538*	0.545*	-0.2016	0.0669
FLA 60 DAS				1.0000	-0.3386	0.533*	0.412*	0.437*	0.1996	0.0005	-0.0543	0.454*
TDW 90 DAS					1.0000	-0.0801	-0.541*	-0.567**	0.547*	0.526*	0.2197	-0.441*
MST 60 DAS						1.0000	0.1654	0.1672	0.0256	0.601**	0.2860	0.427*
CC (15 DAA)							1.0000	0.842**	0.0125	0.0641	-0.3339	0.554**
CC (21 DAA)								1.0000	0.0112	0.0546	-0.3376	0.587**
RWC 60 DAS									1.0000	0.1395	-0.0983	-0.2865
CT (15 DAS)										1.0000	0.731**	0.740**
CT (21 DAS)											1.0000	0.0290
GY												1.0000

PH: Plant height 90 DAS, NOT: Number of tiller 45 DAS, LA: Leaf area 60 DAS, TDW: total dry weight 90 DAS, MST: Membrane thermo-stability 60 DAS, CC 15: Chlorophyll content 15 days after anthesis, CC 21: Chlorophyll content 15 days after anthesis, RWC: Relative water content 60 DAS, CT 15: Canopy temperature 15 days after anthesis, CT 21: Canopy temperature 21 days after anthesis, GY: Grain yield

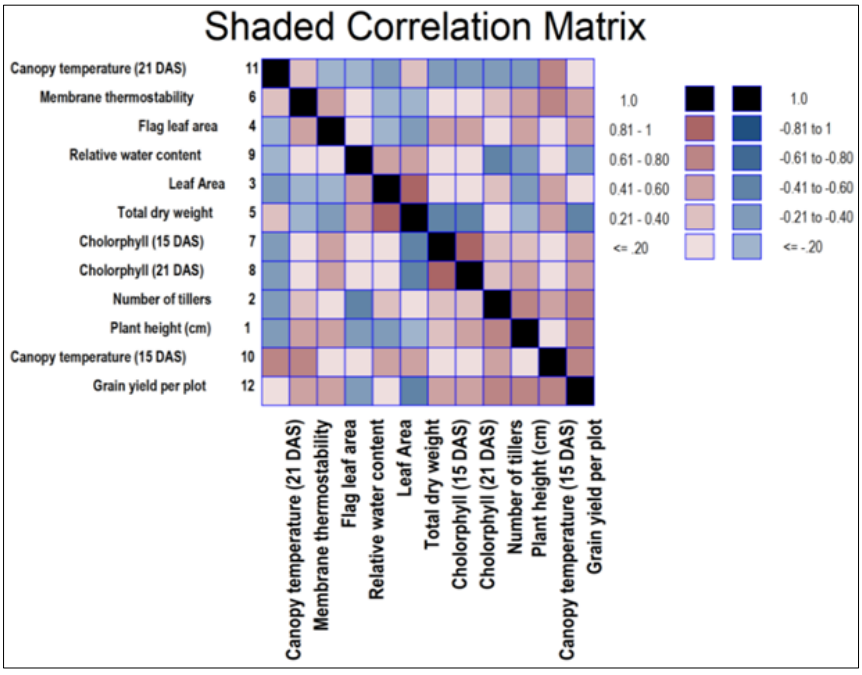

Fig 1: Illustration of Correlation matrix for Correlation coefficient among different morpho-physiological traits under normal sown condition. Darker color in the pallet indicates stronger correlation and vice versa.

3.1.2 Correlation coefficient among different morpho-physiological traits under late sown condition

Data presented in Table 4 and Figure 2 indicates that plant height at 90 days after sowing showed positive significant correlation with grain yield (r = 0.637) followed by Number of tillers 45 DAS (r = 0.658), Flag leaf area 60 DAS (r = 0.537), chlorophyll content at both 15 days and 21 days (r =0.362) this clearly indicates that plant height promotes chlorophyll content resulting in photosynthesis activity and ultimately grain yield. Similar results also depicted by Qaseem *et al.* (2019) [9].

Number of tillers at 45 days after sowing exhibited positively significant correlation with grain yield (r = 0.591), however, this trait exhibited significantly negative correlation with relative water content 60 DAS (r = -0370) and canopy temperature 21 DAA (r = 0.474) indicating that as number of tillers increases it reduces relative water content and canopy temperature because of the tolerance to the heat stress and the

plant is still able to provide grain yield.

Leaf area per plant at 60 DAS has shown significantly positive correlation with total dry weight 90 DAS (r = 0.863) reveals that gradually increase in the leaf area per plant increase in the total dry weight.

Flag leaf area 60 DAS exhibited significantly positive correlation with grain yield (r = 0.419), membrane thermo stability index 60 days after sowing (r = 0.464), chlorophyll content 15 days after anthesis (r = 0.412) and 21 days after anthesis (r = 0.424) indicating that photosynthesis activity increases because of the increase in the leaf area, chlorophyll content and thus promotes grain yield.

Total dry matter production at 90 DAS negatively significant association with chlorophyll content 15 DAA (r = -0.399) and chlorophyll content 21 DAA (r = -0.397).

Membrane thermo stability index at 60 DAS was found to be positively significant correlated with chlorophyll content 15 DAA (r = 0.718), chlorophyll content 21 DAA (r = 0.741), canopy temperature 15 days after anthesis (r = 0.731) and negatively significant with canopy temperature 21 DAA (r = -0.479). Thus results discloses that increase in the electrical conductivity increases the chlorophyll content in the leaves and canopy temperature after 15 days and thus eventually also pushes the heat tolerance in a significant way.

Chlorophyll content 15 DAA has found to be significantly positively correlated with grain yield (r = 0.500) and also with chlorophyll content 21 DAA (r = 0.854) uncovers that increase in the chlorophyll activity promotes the photosynthesis and thus ultimately increases the grain yield.

Chlorophyll content 21 DAA was found significant positively correlated with grain yield (r = 0.514) indicates that increase in the chlorophyll content in the leaves promotes the photosynthesis activity and thus leads to increase in the grain yield, as food material assimilation increases after increase in the photosynthesis activity. Neeru et al., (2017) [8] revealed that under late sown condition, grain yield showed positive and significant correlation with days to anthesis, plant height, effective tillers per meter, canopy temperature and grain weight.

Table 5: Correlation coefficient among different morpho-physiological character with grain yield under late sown condition

Genotypic correlation matrix												
	PH (cm) 90 DAS	**NOT 45 DAS**	**LA 60 DAS**	**FLA 60 DAS**	**TDW 90 DAS**	**MST 60 DAS**	**CC 15 DAA**	**CC 21 DAA**	**RWC 60 DAS**	**CT 15 DAA**	**CT 21 DAA**	**GY**
PH (cm) 90 DAS	1.0000	0.658**	-0.1693	0.537*	-0.1982	0.2355	0.362*	0.362*	-0.2320	-0.0296	-0.1001	0.637**
NOT 45 DAS		1.0000	0.2224	0.2024	0.0629	0.902**	0.3410	0.3377	-0.370*	0.479*	-0.474*	0.591**
LA 60 DAS			1.0000	-0.0348	0.863**	-0.0549	0.1039	0.1127	0.497*	0.2257	-0.2305	0.1007
FLA 60 DAS				1.0000	-0.2468	0.464*	0.412*	0.424*	0.1813	-0.0098	0.0052	0.419*
TDW 90 DAS					1.0000	-0.1669	-0.399*	-0.397*	0.3479	0.1826	0.0671	-0.2511
MST 60 DAS						1.0000	0.718**	0.741**	0.0028	0.731**	-0.479*	0.2664
CC (15 DAA)							1.0000	0.854**	-0.0271	0.0949	-0.437*	0.500*
CC (21 DAA)								1.0000	-0.0345	0.0967	-0.439*	0.514*
RWC 60 DAS									1.0000	0.2137	-0.0390	-0.3008
CT (15 DAS)										1.0000	0.2893	0.3006
CT (21 DAS)											1.0000	0.1033
GY												1.0000

PH: Plant height 90 DAS, NOT: Number of tiller 45 DAS, LA: Leaf area 60 DAS, TDW: total dry weight 90 DAS, MST: Membrane thermo-stability 60 DAS, CC 15: Chlorophyll content 15 days after anthesis, CC 21: Chlorophyll content 15 days after anthesis, RWC: Relative water content 60 DAS, CT 15: Canopy temperature 15 days after anthesis, CT 21: Canopy temperature 21 days after anthesis, GY: Grain yield.

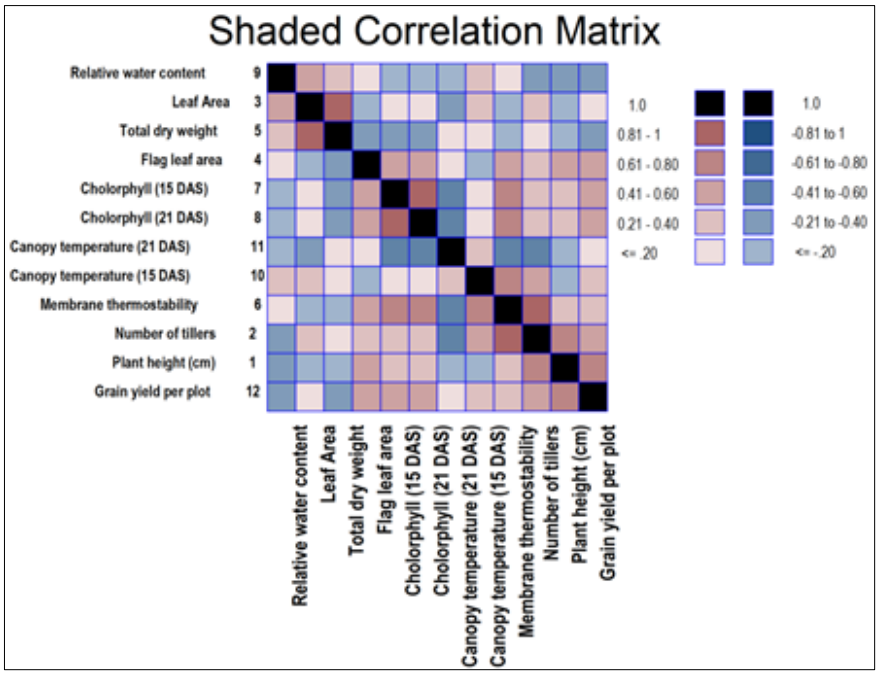

Fig 2: Correlation coefficient among different morpho-physiological character with grain yield under late sown condition

3.2 Path analysis

Path coefficient analysis was used to calculate the direct and indirect contribution of various independent characters with dependent character i.e., grain yield (Dewey and Lu, 1959) [2]. Thus, path analysis can provide a better insight into the cause and effect relationship between different pairs of characters. (Goswami *et al.*, 2020) [5]. Path coefficient analysis was carried out by taking grain yield per plot as a dependent character and rest of the characters as an independent characters.

3.2.1 Path matrix studies among different morpho-physiological traits under normal sown condition

Path analysis for different characters for normal sown condition is depicted in Table 6 and Figure 3. The characters *viz.*, chlorophyll content 15 DAA (3.9211), canopy temperature 21 DAA (2.018), number of tillers 45 DAS (1.7496) and total dry weight 90 DAS (1.4692) showed direct effect on grain yield per plant. This indicates that for selection criteria applied for selecting these characters can ultimately improve grain yield per plant. However, chlorophyll content 15 DAA through chlorophyll content 21 DAA (3.9493), total dry weight 90 DAS via leaf area 90 DAS (1.6528) and chlorophyll content 15 DAA via flag leaf area 60 DAS (1.6149) exhibited highest indirect effect on grain yield.

The characters showing high indirect effect *viz.*, other characters can be used to improve grain yield per plant by selecting one character which ultimately improves the other character and increase grain yield per plant. Sheravat and Kumar (2021) [10] revealed that path analysis for physiological characters shows that the traits chlorophyll content ($SPAD_1$) had maximum direct effect on grain yield and chlorophyll content ($SPAD_2$). Neeru *et al*., 2017 [8] analyzed path analysis in both normal and late sown condition and revealed that effective tillers per meter had highest positive direct on seed yield followed by days to anthesis, grain weight indicating that these were main contributors to grain yield.

Table 6: Path analysis matrix studies among different morpho-physiological character with grain yield under normal sown condition. Diagonal values indicate direct effect and off-diagonal values shows indirect effect.

Path matrix of grain yield / plot												
	PH (cm) 90 DAS	**NOT 45 DAS**	**LA 90 DAS**	**FLA 60 DAS**	**TDW 90 DAS**	**MST 60 DAS**	**CC 15 DAA**	**CC 21 DAA**	**RWC 60 DAS**	**CT 15 DAA**	**CT 21 DAA**	**GY**
PH (cm) 90 DAS	-0.1927	-0.1321	0.0419	-0.1079	0.0367	-0.0964	-0.0733	-0.0779	0.0589	-0.0287	0.04	0.706**
NOT 45 DAS	1.1989	1.7496	0.4339	0.3414	0.3243	0.6698	0.6322	0.6599	-0.746	0.7391	-0.4764	0.638**
LA 60 DAS	0.2082	-0.2377	-0.9586	0.0203	-1.0784	0.1017	-0.1027	-0.1084	-0.5154	-0.522	0.1933	0.0669
FLA 60 DAS	-0.0862	-0.03	0.0033	-0.1539	0.0521	-0.082	-0.0634	-0.0672	-0.0307	-0.0001	0.0084	0.454*
TDW 90 DAS	-0.2797	0.2723	1.6528	-0.4974	1.4692	-0.1177	-0.7953	-0.8332	0.8038	0.7727	0.3228	-0.441*
MST 60 DAS	0.1786	0.1367	-0.0379	0.1901	-0.0286	0.357	0.0591	0.0597	0.0091	0.2145	0.1021	0.427*
CC (15 DAA)	1.4916	1.4169	0.4203	1.6149	-2.1226	0.6486	3.9211	3.9493	0.049	0.2512	-1.3093	0.554**
CC (21 DAA)	-0.8917	-0.8317	-0.2492	-0.9634	1.2505	-0.3686	-2.2208	-2.205	-0.0248	-0.1204	0.7444	0.587**
RWC 60 DAS	-0.1848	-0.2578	0.3252	0.1207	0.3309	0.0155	0.0076	0.0068	0.6047	0.0844	-0.0595	-0.2865
CT (15 DAS)	-0.3168	-0.8982	-1.1579	-0.001	-1.1184	-1.2777	-0.1362	-0.1161	-0.2967	-2.1263	-1.5548	0.740**
CT (21 DAS)	-0.4193	-0.5495	-0.4069	-0.1096	0.4434	0.5772	-0.6738	-0.6813	-0.1985	1.4757	2.018	0.0290
Partial R^2	-0.1361	1.117	-0.0642	-0.0699	-0.6479	0.1526	2.174	-1.2933	-0.1732	-1.5735	0.0585	

PH: Plant height 90 DAS, **NOT:** Number of tiller 45 DAS, **LA:** Leaf area 60 DAS, **FLA:** Flag leaf area, **TDW:** total dry weight 90 DAS, **MST:** Membrane thermo-stability 60 DAS, **CC 15:** Chlorophyll content 15 days after anthesis, **CC 21:** Chlorophyll content 15 days after anthesis, **RWC:** Relative water content 60 DAS, **CT 15:** Canopy temperature 15 days after anthesis, **CT 21:** Canopy temperature 21 days after anthesis, **GY:** Grain yield.

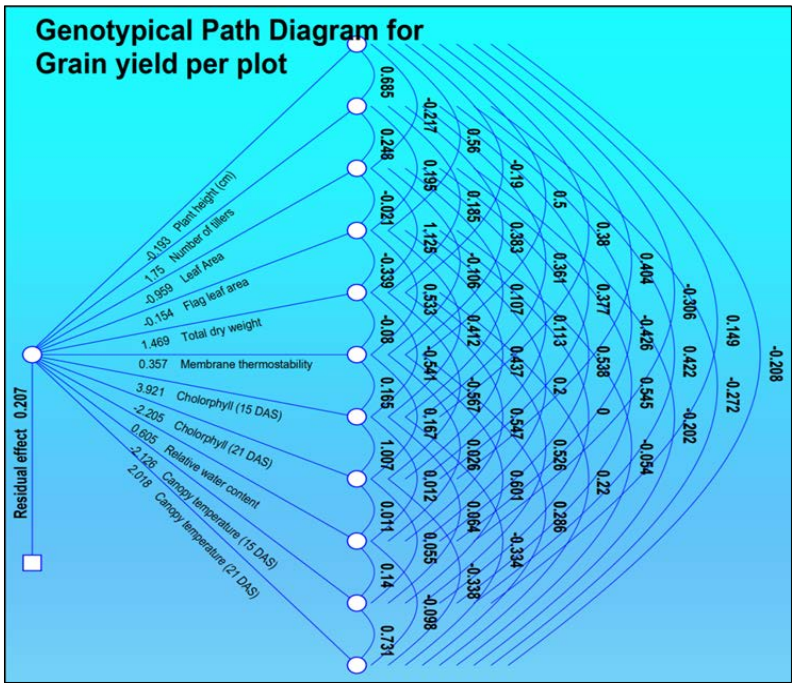

Fig 3: Genotypic path analysis in wheat genotypes under normal sown condition.

3.2.2 Path analysis matrix studies among different morpho-physiological traits under late sown condition

Path analysis for different characters for normal sown condition is depicted in Table 7 and Figure 4.

The characters *viz.*, leaf area (1.8165), chlorophyll content 15 DAA (1.7171), canopy temperature 15 DAA (0.5376) and canopy temperature 21 DAS (0.3276) showed direct effect on grain yield per plant. However, chlorophyll content 21 DAA via total dry weight 90 DAS (0.7686), chlorophyll content 15 DAA through flag leaf area 60 DAS (0.7069) and chlorophyll content 15 DAA through plant height 90 DAS (0.6207) exhibited highest indirect effect on grain yield. Indicating that selecting these characters can ultimately improve grain yield per plant. Khanal *et al.* (2020) [7] analyzed path analysis and revealed that biomass weight has maximum positive direct effect on grain yield followed by harvest index, days to booting, days to flowering, chlorophyll content ($SPAD_3$), root angle of basket condition, number of root, number of grains per spike, and number of tiller per meter square. On the other hand, days to booting, flag leaf area, physiological maturity, chlorophyll content ($SPAD_1$), chlorophyll content ($SPAD_2$), root length, days to flag leaf senescence, plant height, ctd_2, and thousand kernel weight showed the negative direct effect on grain yield.

Table 7: Path analysis matrix studies among different morpho-physiological character with grain yield under late sown condition

Path matrix of grain yield / plot												
	PH (cm) 90 DAS	**NOT 45 DAS**	**LA 90 DAS**	**FLA 60 DAS**	**TDW 90 DAS**	**MST 60 DAS**	**CC 15 DAA**	**CC 21 DAA**	**RWC 60 DAS**	**CT 15 DAA**	**CT 21 DAA**	**GY**
PH (cm) 90 DAS	0.1273	0.0837	-0.0215	0.0683	-0.0252	0.0300	0.0460	0.0460	-0.0295	-0.0038	-0.0127	0.637**
PH (cm) 90 DAS	0.4550	0.6917	0.1538	0.1400	0.0435	0.6236	0.2359	0.2336	-0.2562	0.3316	-0.3281	0.591**
NOT 45 DAS	-0.3075	0.4040	1.8165	-0.0632	1.5679	-0.0998	0.1887	0.2048	0.9029	0.4100	-0.4187	0.1007
LA 60 DAS	0.1994	0.0752	-0.0129	0.3717	-0.0917	0.1724	0.1530	0.1577	0.0674	-0.0036	0.0019	0.419*
FLA 60 DAS	0.3836	-0.1218	-1.6707	0.4777	-1.9356	0.3230	0.7715	0.7674	-0.6735	-0.3534	-0.1298	-0.2511
TDW 90 DAS	-0.1919	-0.7345	0.0448	-0.3778	0.1360	-0.8147	-0.5852	-0.6037	-0.0023	-0.5956	0.3898	0.2664
MST 60 DAS	0.6207	0.5855	0.1784	0.7069	-0.6844	1.2334	1.7171	1.7242	-0.0465	0.1629	-0.7508	0.500*
CC (15 DAA)	-0.7008	-0.6547	-0.2186	-0.8228	0.7686	-1.4365	-1.9466	-1.9386	0.0668	-0.1875	0.8516	0.514*
CC (21 DAA)	0.1003	0.1600	-0.2148	-0.0783	-0.1503	-0.0012	0.0117	0.0149	-0.4321	-0.0923	0.0168	-0.3008
RWC 60 DAS	-0.0159	0.2577	0.1213	-0.0052	0.0982	0.3930	0.0510	0.0520	0.1149	0.5376	0.1555	0.3006
CT (15 DAS)	-0.0328	-0.1554	-0.0755	0.0017	0.0220	-0.1568	-0.1432	-0.1439	-0.0128	0.0948	0.3276	0.1033
CT (21 DAS)	0.637**	0.591**	0.1007	0.419*	-0.2511	0.2664	0.500*	0.514*	-0.3008	0.3006	0.1033	1.0000
Partial R^2	0.0811	0.4091	0.1830	0.1557	0.4861	-0.2170	0.8582	-0.9971	0.1300	0.1616	0.0338	

PH: Plant height 90 DAS, NOT: Number of tiller 45 DAS, LA: Leaf area 60 DAS, TDW: total dry weight 90 DAS, MST: Membrane thermo-stability 60 DAS, CC 15: Chlorophyll content 15 days after anthesis, CC 21: Chlorophyll content 15 days after anthesis, RWC: Relative water content 60 DAS, CT 15: Canopy temperature 15 days after anthesis, CT 21: Canopy temperature 21 days after anthesis, GY: Grain yield.

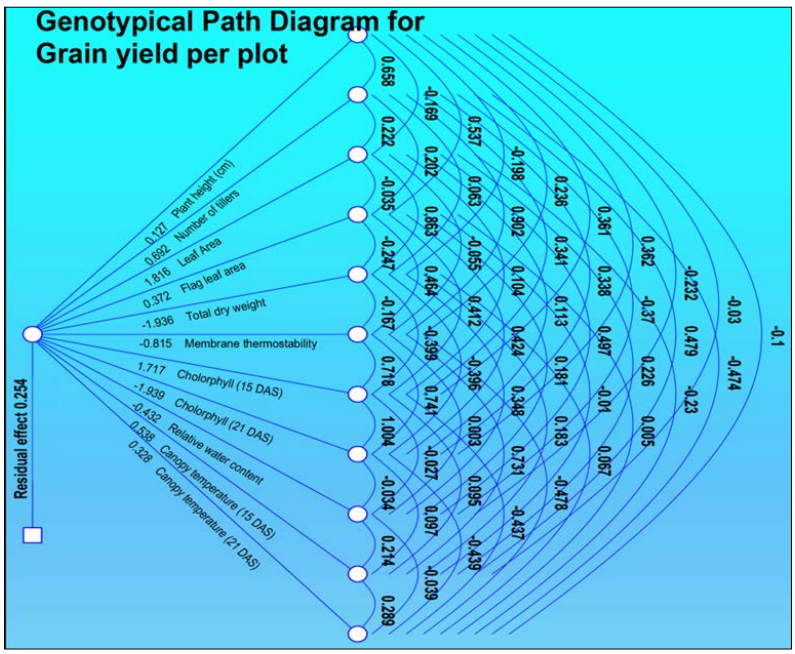

Fig 4: Correlation and path analysis in wheat genotype under late sown condition.

4. Conclusion

Following are the conclusions drawn out of the experiment carried out for normal and late sowing;

1. By contracting their stomata, wheat plants may increase the temperature of their canopy. This action lowered transpiration and water loss, which in turn hindered the synthesis of chlorophyll and eventually photosynthesis attributable to structural changes in the chloroplasts that followed.
2. Relative water content is a useful predictor of heat tolerance because it represents the stability of the membrane and the equilibrium between water supply and

evapotranspiration.

3. Application of exogenous protectants to seeds or plants, marker-assisted selection, screening of existing germplasm under field trials, and mapping of quantitative trait loci transmitting heat tolerance are all effective methods for controlling heat stress in wheat.

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